IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF OKLAHOMA

STATE OF OKLAHOMA, ex rel. W.A. DREW EDMONDSON, in his capacity as ATTORNEY GENERAL OF THE STATE OF OKLAHOMA and OKLAHOMA SECRETARY OF THE ENVIRONMENT C. MILES TOLBERT, in his capacity as the TRUSTEE FOR NATURAL RESOURCES FOR THE STATE OF OKLAHOMA Plaintiffs, vs. 1. TYSON FOODS, INC., 2. TYSON POULTRY, INC., 3. TYSON CHICKEN, INC., 4. COBB-VANTRESS, INC., 5. AVIAGEN, INC., 6. CAL-MAINE FOODS, INC., 7. CAL-MAINE FARMS, INC., 8. CARGILL, INC., 9. CARGILL TURKEY PRODUCTION, LLC., 10. GEORGE'S, INC., 11. GEORGE'S FARMS, INC., 12. PETERSON FARMS, INC., 13. SIMMONS FOODS, INC., and 14. WILLOW BROOK FOODS, INC., Defendants.	)	Case No. 4:05-cv-00329-GKF-SAJ

EXPERT REPORT OF DR. CHRISTOPHER M. TEAF

Qualifications & Experience

1. My name is Dr. Christopher M. Teaf. I am over 18 years of age and am competent to testify. All opinions presented in this statement reflect personal knowledge based on information and data that I have reviewed in this case. All

less likely to be investigated than acute diseases characterized by short incubation periods, serious illness requiring medical treatment, and those having recognized etiologies (Lee et al., 2002; Blackburn et al., 2004). Individual sensitivity and enhanced susceptibility among groups such as children, the elderly, and the immuno-compromised, further complicates the effectiveness and applicability of disease surveillance (WHO, 2003; NRC, 2004).

41. It is clear that many diseases are commonly under-reported, given the limitations of the passive disease surveillance systems presently in place. Multiple factors play a role in whether disease outbreaks are recognized, investigated, and/or reported, which typically will result in under-reporting of the true illness rate (Lee et al., 2002; Blackburn et al., 2004; Liang et al., 2006; Craun & Calderon, 2006;). Multiple studies (Lee et al., 2002; Yoder et al., 2004; Blackburn et al., 2004; Liang et al., 2006) have concluded that the data which are collected most commonly pertain to "outbreaks," with no mechanism to include seemingly sporadic cases, and therefore the data do not necessarily represent actual endemic trends with waterborne illnesses. The observations already available concerning disease occurrence in northeastern Oklahoma underscore the potential for increases in infectious diseases related to land disposal of poultry waste in large quantities.

42. The bacterial impacts associated with the application of poultry waste to lands in the Illinois River Watershed represent an imminent and substantial endangerment to human health.

Trihalomethanes (THMs) and Haloacetic Acids (HAA5s)

43. One human health risk associated with the spreading of poultry waste on agricultural fields in large quantities, with associated runoff, is related to the formation of potentially carcinogenic substances that may occur in treated drinking water supplies (Cooke and Welch, 2008). Formation of these products can occur during the normal municipal treatment of water prior to distribution, and is a result of increased organic matter in the raw intake water which combines with chlorine to form "disinfection byproducts" (DBP's). Several examples of which are trihalomethanes (THMs) and

haloacetic acids (HAA5s). One direct and/or indirect source of this increased organic matter is contaminated runoff from fields on which poultry waste have been spread. Studies have shown there to be an increase in the poultry population and thus an increase in the amount of waste generated by poultry dating back as far as 1950 (Engel, 2008; Fisher, 2008). The total amount of waste generated annually within the IRW was estimated to be over 300,000 tons (Fisher, 2008). Increased organic matter, in conjunction with excessive nutrients, primarily nitrogen and phosphorus, from poultry waste are principal recognized causes of eutrophication, algal growth, and water quality degradation (Lee and Jones, 1991; Cooke and Welch, 2008; PEW, 2008). This scenario is illustrated in Figure T1. The principal source of phosphorus to Lake Tenkiller has been attributed to poultry waste applied to pastures that eventually reaches the Illinois River and then Lake Tenkiller (Engel, 2008; Cooke and Welch, 2008). One of the most effective methods to control eutrophication and restore water quality is by reducing the excessive phosphorus sources (Sas et al., 1989; Lee and Jones, 1991; Slaton et al., 2004; Cooke and Welch, 2008), which in this case could be accomplished by decreasing or eliminating the contribution made by poultry waste.

44. Nutrient pollution to surface waters from "insufficiently treated sewage, runoff from fertilized agricultural areas and lawns, manure and more complex effluent from livestock industries" (Briand et al., 2003), can and does result in eutrophication and algal proliferation. The increase in these algal communities, including those of cyanobacteria, disrupt the complex aquatic environment within the system, which can lead to oxygen depletion, taste and odor issues, and the formation of organics in the water (Fruh, 1967; Hoehn et al., 1980; van Steenderen et al., 1988; Cooke and Welch, 2008; Stevenson, 2008). Cyanobacteria, such as *Microcystis aeruginosa*, have been shown to be productive precursors of trihalomethane disinfection byproducts in treated water supplies (van Steenderen et al., 1988).

45. Chlorine treatment, which has been the most widely used and cost effective disinfectant practice for U.S. public or private water supplies since the early-1900's and which is commonly used in wastewater treatment facilities (NAS, 1987; Bull et al., 1995), may result in the formation of chemicals known as DBPs, which are of ongoing health

concern (Wistrom et al., 1996; USEPA, 2006c). These DBPs include the predominant class of trihalomethanes, or THMs (consisting of chloroform, bromodichloromethane, dibromochloromethane, bromoform), as well as the haloacetic acids, or HAA5s, (consisting of monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid). In addition to these groups, other disinfection byproducts are continually being evaluated for occurrence, toxicity and potential human health risk (Krasner et al., 2006). The formation of DBPs in treated water is a well-recognized phenomenon, and depends on factors such as pH, nature/concentration of organic matter, chlorination contact time, water temperature, chlorine dose, chlorine residual, and bromide concentration (Stevens et al., 1976; Reckhow and Singer, 1990; OWRB, 2005; USEPA, 2006b; Gopal, 2007; Cooke and Welch, 2008).

46. The formation of DBPs is correlated significantly with the content of dissolved organics in raw water (Martin et al., 1993; Stepczuk et al., 1998; Stuart et al., 1999; Gallard and Gunten, 2002; Brown, 2003). Under normal circumstances, naturally occurring organic material (NOM) is a principal precursor with which halogens (e.g., chlorine and bromine) can react to form DBPs (Rook, 1976; Oliver and Lawrence, 1979; Marhaba and Kochar, 2000; Gopal et al., 2007; Richardson et al., 2007; Wang et al., 2007). However, nutrient enrichment (e.g., loading of phosphorus, Total Organic Carbon (TOC), and nitrogen) in water bodies from activities such as spreading of poultry waste to pasture lands, can increase organic matter concentrations and dramatically increase or speed up eutrophication processes in lakes, often with accompanying increases in algal growth, which also can result in increased DBPs (Peterson et al., 1993; Preusch et al., 2002; Lee et al., 2007; Cooke and Welch, 2008). Water samples taken directly following waste application and right after rainfall (Edge-of-Field) from the IRW show high levels of TOC.

47. Excess nutrient loading and nutrient pollution in some circumstances can originate from urban runoff, industry, automobiles, and human sewage. However, in many areas the largest source comes from agriculture and from uses of manure produced by livestock, including poultry, on fields (Anderson et al., 2002; Tang et al.,

2005). Engel (2008) concluded that excess amounts of these fertilizer constituents, in the form of manure and litter spread in quantities beyond that which can be sequestered by plants and soil, lead to increased amounts of phosphorus in runoff. In addition, Engel (2008) concluded that close to 80% of the net annual phosphorus contribution to the IRW comes from poultry. High levels of phosphorus in runoff act to fertilize the aquatic life in water, leading to excessive growth of algae and underwater plants that can lead to production of DBP's (Hoehn et al., 1980; Dore et al., 1982; Lee and Jones, 1991). Enhanced nutrient loading can also increase the formation of *Cladophora*, a branching filamentous green alga, often times found on rocky substances. Stevenson (2008) showed that the algal biomass density was related to total phosphorus concentrations and poultry house density along the streams and rivers in the Illinois River Watershed. Other technical literature has shown that *Cladophora* can be a secondary habitat for pathogenic bacteria (Byappanahalli et al., 2003; Whitman et al., 2003; Ishii et al., 2006), which greatly extends the survivability of the bacteria in the environment. When levels of TOC and DOC decrease, THM precursors and THMs levels decrease as well.

48. The U.S. EPA, the International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP) and other researchers have concluded that the weight of evidence from animal and human studies warrants classification of the THMs (chloroform, bromodichloromethane, dibromochloromethane, bromoform), as well as at least two of the haloacetic acids (dichloroacetic acid, trichloroacetic acid) as Probable or Possible human carcinogens (Cantor et al., 1978; Morris et al., 1992; Nokes et al., 1999; USEPA, 2007a; Villanueva et al., 2007). One case-control study from Canada concluded that the risk of bladder cancer increased with both duration and concentration of DBP's in household water supplies (King and Marrett, 1996). In addition to the ingestion route, Villanueva et al. (2007) showed that inhalation and dermal absorption of THMs from household activities and swimming in pools may be associated with the development of cancer. A pooled analysis of six case-control studies, conducted by Villanueva et al. (1994), strengthened the conclusion that the risk of bladder cancer increases with long-term exposure to DBPs at levels that are currently observed in many

industrialized countries. In addition, a meta-analysis performed by Morris et al. (1992) concluded that there was a positive relationship between the consumption of DBP's in drinking water and bladder and rectal cancer in humans.

49. In recent years, U.S. EPA has set increasingly stringent limits on the allowable amounts of THMs in drinking water that determine what treatment facilities must achieve. In 1998, U.S. EPA issued the Stage 1 Disinfectants and Disinfection Byproducts Rule (Stage 1 DBPR), which reduced the maximum contaminant level (MCL) for THMs from 0.10 mg/L to 0.080 mg/L (100 to 80 parts per billion) and included additional compliance obligations for community water systems that chemically disinfect their water for primary or residual treatment (USEPA, 1998). Based upon results of testing following implementation of the Stage 1 rule, U.S. EPA subsequently determined that additional regulation beyond Stage I, in the form of the Stage 2 Disinfectant Byproducts Rule (Stage 2 DBPR), was needed to adequately protect human health (ADOH/DoE, 2003; USEPA, 2006c).

50. The Stage 2 DBPR places further restrictions on production and monitoring of DBPs, establishing revised Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) for several of the DBPs. The concentration limits (MCLs) imposed by the Stage 2 DBP rule are, by definition, based upon a combination of considerations regarding health effects, technical feasibility and costs. In contrast, the development of MCLGs is based on health effects considerations only. For example, the MCLG for chloroform is 0.070 mg/L, while the MCL for total THMs, which typically are dominated by chloroform, is 0.080 mg/L. The MCLGs for two common HAA5s monochloroacetic acid and trichloroacetic acid, are 0.070 mg/L and 0.02 mg/L, respectively, while the current MCL for HAA5s is 0.060 mg/L. For the DBPs bromodichloromethane, bromoform, and dichloroacetic acid, the MCLG is zero, reflecting the ideal position that potential carcinogens should not be present in drinking water at any concentration. From a strictly health-based perspective (i.e., theoretical calculation using exposure guidelines) the following restrictive water concentrations were identified by USEPA (2006c) as being necessary to meet the standard regulatory benchmark of 1-in-one million cancer risk:

•	dibromochloromethane	0.0009 mg/L
•	bromodichloromethane	0.001 mg/L
•	bromoform	0.008 mg/L
•	dichloroacetic acid	0.0007 mg/L

In addition, the 2008 U.S. EPA Region 6 risk-based screening level for chloroform in residential water is 0.00017 mg/L (0.17 μg/L) (U.S. EPA, 2008). Wang (2007) has recently shown that water quality standards for THMs need to be reviewed to account for the different risks resulting from each individual THM species.

51. The State of Oklahoma requires that all public water systems monitor the finished water supplies for both total THMs (TTHM) and HAA5s. Available data through early-2008 from ODEQ was reviewed for the 18 currently active public water systems (Figure T2) that draw water from the Illinois River Watershed. There were 51 exceedances of the chloroform maximum contaminant level goal (MCLG) of 0.07 mg/L and 16 near exceedances (defined for purposes of this report as being within 10% of the MCLG). There were 56 exceedances of the TTHM standard of 0.08 mg/L and 29 near exceedances, and 35 exceedances of the HAA5s standard of 0.06 mg/L and 11 near exceedances. It should be noted that TTHM and HAA5s were not reported until late 2003. Prior to that time, when data for each individual component was available, TTHM values were estimated by summing these components. Currently, ODEQ has reported close to 30 violations for MCL average exceedances of either TTHM or HAA5s in tap water at customer facilities, or for sampling/reporting violations (ODEQ, 2008). There were also a multitude of exceedances of the risk-based criteria for bromodichloromethane, dibromochloromethane, and chloroform. Table T1 compares the exceedances between the risk based values and the listed MCL or MCLG values. Risk based values were exceeded over 90% of the time for both chloroform and bromodichloromethane, while the risk based value for dibromochloromethane was exceeded about 56% of the time. Stated simply, if risks of this magnitude were found at a waste disposal site or an industrial contamination site, in my experience they would require attention and remediation.

52. CDM collected water samples on three separate occasions in 2006 from 5 locations within three different IRW public water systems and analyzed them for TTHM and HAA5s. These locations are depicted in Figure T3. Of the total 45 samples collected, there were 6 exceedances and 5 near exceedances of the TTHM MCL (24%) and 3 exceedances and 1 near exceedance of the HAA5s MCL (9%). All of the samples exceeded the risk-based values for bromodichloromethane and dibromochloromethane and dichloroacetic acid, while two of the samples exceeded the individual chloroform MCLG of 0.070 mg/L. Six of the samples were greater than the MCLG of 0.02 mg/L for trichloroacetic acid. These results are illustrated in Table T2. In addition, raw water samples collected during the recreational season of 2005, 2006 and 2007 were evaluated for THM-forming potential (THMFP; CDM, 2008) and 71% of the results (57/80) showed values in excess of the TTHM MCL at twelve different locations along the Illinois River and in Lake Tenkiller. Table T3 shows the average THMFP from five PWAs. These report several of the larger systems which withdraw, treat and distribute water from the IRW.

53. Beyond the increased human health risks, elevated levels of THMs and HAA5s in drinking water often result in esthetic concerns (e.g., disagreeable taste and odors) in water supplies at concentrations which are at or near the drinking water standards (USEPA, 2006c). Thus, the water supply may be in compliance with regulatory numerical standards, but may not meet the Oklahoma narrative standards for water supplies. This general narrative criteria, found in OAC 785:45-5-9, states that "taste and odor producing substances from other than natural origin shall not interfere with the production of a potable water supply by modern treatment methods…" and "shall be maintained at all times to all surface waters of the state" (OAC, 2007). This criterion has not been met on many occasions in the IRW. In addition, the general criteria for public and private water supplies found in OAC 785:45-5-10 (5) (A) states that "The quality of the surface waters of the state which are designated as public or private water supplies shall be protected, maintained, and improved when feasible, so that the waters can be used as sources of public and private raw water supplies". In this case the water bodies in the IRW are not being adequately protected. Also found in that criterion is OAC

785:45-5-10(5) (B) which states: "These waters shall be maintained so that they will not be toxic, carcinogenic, mutagenic, or teratogenic to humans" (OAC, 2007). The reported TTHM and HAA5s concentrations detected in IRW waters clearly demonstrate that this criterion is not being met.

54. The impacts from increased disinfection byproducts (e.g., THMs and HAA5s) associated with the application of poultry waste to lands in the Illinois River Watershed represent an imminent and substantial endangerment to human health.

Cyanobacteria

55. Cyanobacteria, also often termed "harmful blue-green algae", are photosynthetic single-celled aquatic organisms that can produce potent toxins (e.g., microcystins, cylindrospermopsin, saxitoxins). It is well-documented that those toxins may be poisonous to aquatic organisms, to terrestrial animals, and to humans when present in water bodies at sufficient concentrations (Duy et al., 2000; Stewart, 2004; Falconer and Humpage, 2005; Janse et al., 2005; Health Canada, 2007; Cooke and Welch, 2008). The production of cyanobacterial toxins is influenced by a wide array of environmental conditions such as nutrient availability, light conditions, and temperature (Carson, 2000). Human health hazards occur from the following exposure routes: oral (through accidental ingestion of contaminated recreational water or ingestion of contaminated raw drinking water); dermal (through direct contact of exposed body parts with contaminated recreational waters); and inhalation (through airborne aerosols). Carmichael (2001) also reported exposure via the intravenous route in a dialysis clinic in Brazil as a result of contaminated local water supplies.

56. As ancient life forms often found living near the surface of warm water lakes and reservoirs, cyanobacteria are a well-recognized health hazard in many water supplies worldwide, including those in Europe, Australia, Asia and the Americas (WHO, 2000; Mankiewicz et al., 2005; Boaru et al., 2006; Stewart et al., 2006b). There are nearly 2,000 identified species of cyanobacteria, with more than 50 being recognized as potentially toxic to humans and animals (WHO, 2003). As noted in Chorus et al. (2000), "Cyanobacterial toxins occur naturally, but pollution with nutrients from agriculture